UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

BULLETIN 1753F-206(PE-86)

SUBJECT: **REA Specification for Filled Buried Wires**

TO: All Telephone Borrowers
REA Telephone Staff

EFFECTIVE DATE: December 20, 1993.

EXPIRATION DATE: Date of change in 7 CFR 1755.860 by rulemaking.

OFFICE OF PRIMARY INTEREST: Outside Plant Branch, Telecommunications Standards Division.

PREVIOUS INSTRUCTIONS: This bulletin replaces REA Bulletin 345-86, REA Specification for Filled Buried Service Wire, PE-86, issued October 7, 1982.

FILING INSTRUCTIONS: Discard REA Bulletin 345-86, REA Specification for Filled Buried Service Wire, PE-86, dated October 7, 1982, and replace with this bulletin. File with 7 CFR 1755 and on REANET.

PURPOSE: This specification covers REA requirements for filled buried wires intended for direct burial as a subscriber drop and/or distribution wire. This bulletin is a user friendly guide and a reformat of the text codified in 7 CFR §1755.860 published at 58 FR 61002, dated November 19, 1993.

Every effort has been made to ensure the accuracy of this document. However, in case of discrepancies, the regulations at 7 CFR §1755.860 are the authorized sources.

Wally Beyer — 01/14/94

Administrator — Date

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ABBREVIATIONS

ANSI	American National Standards Institute
ASTM	American Society For Testing and Materials
AWG	American Wire Gauge
°C	Centigrade temperature scale
dc	Direct current
dB/1000 ft	Decibels per 1000 feet
dB/km	Decibels per 1 kilometer
dB/mile	Decibels per 1 mile
EIA	Electronic Industries Association
F_o	Known frequency
F_x	New frequency
FEXT	Far-end crosstalk
ft	Feet
g	Grams
HD	High density polyethylene compound
IACS	International Annealed Copper Standard
in.	Inches
in./min	Inches per 1 minute
K_o	Known far-end crosstalk
K_x	New far-end crosstalk
km	Kilometer
kHz	Kilohertz
kPa	Kilopascals
kV	Kilovolts
L_o	Known length
L_x	New length
lbf	Pound force
lbf-ft	Pound force-foot
LDHMW	Low density, high molecular weight polyethylene compound
LLDHMW	Linear low density, high molecular weight polyethylene compound
m	Meter
Max.	Maximum
Min.	Minimum
MD	Medium density polyethylene compound
MHz	Megahertz
micromhos/km	Micromhos per 1 kilometer
MPa	Megapascals
mm	Millimeter
mm/min	Millimeters per 1 minute
N	Newton
N-m	Newton-meter
nF/km	Nanofarad per 1 kilometer
nF/mile	Nanofarad per 1 mile
ohms-cm	Ohms-centimeter
ohms/1000 ft	Ohms per 1000 feet
pF/km	Picofarads per 1 kilometer
pF/1000 ft	Picofarads per 1000 feet
psi	Pounds per square inch

psig	Pounds per square inch gauge
REA	Rural Electrification Administration
Yoc	Open circuit admittance
Zsc	Short circuit impedance

1. SCOPE

1.1 This specification covers the requirements for filled buried wires intended for direct burial as a subscriber drop and/or distribution wire.

1.1.1 The conductors are solid copper, individually insulated with an extruded solid insulating compound.

1.1.2 The insulated conductors are twisted into pairs (a star-quad configuration is permitted for the two pair wires) which are then stranded or oscillated to form a cylindrical core.

1.1.3 A moisture resistant filling compound is applied to the stranded conductors completely covering the insulated conductors and filling the interstices between the pairs.

1.1.4 The wire structure is completed by the application of an optional core wrapping material, an inner jacket, a flooding compound, a shield, a flooding compound and an overall plastic jacket.

1.2 The number of pairs and gauge size of conductors which are used within the REA program are provided in the following table:

AWG	22	24
Pairs	2	2
	3	3

1.3 All wires sold to REA borrowers for projects involving REA loan funds under this specification must be accepted by REA Technical Standards Committee "A" (Telephone). For wires manufactured to this specification, all design changes to an accepted design must be submitted for acceptance. REA will be the sole authority on what constitutes a design change.

1.4 Materials, manufacturing techniques or wire designs not specifically addressed by this specification may be allowed if accepted by REA. Justification for acceptance of modified materials, manufacturing techniques or wire designs must be provided to substantiate product utility and long term stability and endurance.

2. CONDUCTORS AND CONDUCTOR INSULATION

2.1 Each conductor must be a solid round wire of commercially pure annealed copper. Conductors must meet the requirements of ASTM B 3-90 except that requirements for Dimensions and Permissible Variations are waived and elongation requirements are superseded by this specification.

2.2 The minimum conductor elongation in the final wire must comply with the following limits when tested in accordance with ASTM E 8-91.

Conductor - AWG	Minimum Elongation - Percent
22	20
24	16

2.3 Joints made in conductors during the manufacturing process may be brazed, using a silver alloy solder and nonacid flux, or they may be welded using either an electrical or cold welding technique. In joints made in uninsulated conductors, the two conductor ends must be butted. Splices made in insulated conductors need not be butted but may be joined in a manner acceptable to REA.

2.4 The tensile strength of any section of a conductor containing a factory joint must not be less than 85 percent of the tensile strength of an adjacent section of the solid conductor of equal length without a joint.

Engineering Information: The sizes of wire used and their nominal diameters shall be as shown in the following table:

AWG	Nominal Diameter - mm (in.)	
22	0.643	(0.0253)
24	0.511	(0.0201)

2.5 Each conductor must be insulated with either a colored, solid, insulating grade, high density polyethylene or crystalline propylene/ethylene copolymer or with a solid natural primary layer and a colored, solid outer skin using one of the insulating materials listed in Paragraphs 2.5.1 through 2.5.2 of this specification.

2.5.1 The polyethylene raw material selected to meet the requirements of this specification must be Type III, Class A, Category 4 or 5, Grade E9 in accordance with ASTM D 1248-84(1989).

2.5.2 The crystalline propylene/ethylene raw material selected to meet the requirements of this specification must be Class PP 200B 40003 E11 in accordance with ASTM D 4101-82(1988).

2.5.3 Raw materials intended as conductor insulation furnished to these requirements must be free from dirt, metallic particles and other foreign matter.

2.5.4 All insulating raw materials must be accepted by REA prior to their use.

2.6 All conductors in any single length of wire must be insulated with the same type of material.

2.7 A permissible overall performance level of faults in conductor insulation must average not greater than one fault per 12,000 conductor meters (40,000 conductor ft) for each gauge of conductor.

2.7.1 All insulated conductors must be continuously tested for insulation faults during the twinning operation with the method of test acceptable to REA. The length count and number of faults must be recorded. The information must be retained for a period of 6 months and be available for review by REA when requested.

2.7.2 The voltages for determining compliance with the requirements of Paragraph 2.7, are as follows:

AWG	DC Voltages (kV)
22	6.0
24	5.0

2.8 Repairs to the conductor insulation during manufacturing are permissible. The method of repair must be accepted by REA prior to its use. The repaired insulation must be capable of meeting the relevant electrical requirements of this specification.

2.9 All repaired sections of insulation must be retested in the same manner as originally tested for compliance with the requirements of Paragraph 2.7 of this specification.

2.10 Colored insulating material removed from or tested on the conductor, from a finished wire, must be capable of meeting the following performance requirements.

Property	Polyethylene	Crystalline Propylene/Ethylene Copolymer
Melt Flow Rate		
Percent increase from raw material, Maximum		
<0.5 (Initial Melt Index)	50	--
0.5-2.00 (Initial Melt Index)	25	--
≤5.0 (Initial Melt Index)	--	110
Tensile Strength		
Minimum, MPa (psi)	16.5 (2,400)	21.0 (3,000)
Ultimate Elongation		
Minimum, Percent	300	300
Cold Bend		
Failures, Maximum	0/10	0/10

<u>Shrinkback</u>		
Maximum, mm (in.)	10 (0.375)	10 (0.375)
<u>Oxygen Induction Time</u>		
Minimum, Minutes	20	20

2.11 <u>Testing Procedures:</u> The procedures for testing the insulation samples for compliance with Paragraph 2.10 of this specification must be as follows.

2.11.1 <u>Melt Flow Rate:</u> The melt flow rate must be determined as described in ASTM D 1238-90b. Condition E must be used for polyethylene. Condition L shall be used for crystalline propylene/ethylene copolymer. The melt flow test must be conducted prior to the filling operation.

2.11.2 <u>Tensile Strength and Ultimate Elongation:</u> Samples of the insulation material, removed from the conductor, must be tested in accordance with ASTM D 4565-90a using the following conditions. The minimum length of unclamped specimen must be 50 mm (2.0 in.). The minimum speed of jaw separation must be 25 mm (1.0 in.) per minute per 25 mm (1.0 in.) of unclamped specimen. The temperature of specimens and surrounding must be 23 ± 1°C.

> Note: Quality assurance testing at a jaw separation speed of 500 mm/min (20 in./min) is permissible. Failures at this rate must be retested at the 50 mm/min (2 in./min) rate to determine specification compliance.

2.11.3 <u>Cold Bend:</u> Samples of the insulation material on the conductor must be tested in accordance with ASTM D 4565-90a at a temperature of -40 ± 1°C with a mandrel diameter equal to 3 times the outside diameter of the insulated conductor. There must be no cracks visible to normal or corrected-to-normal vision.

2.11.4 <u>Shrinkback:</u> Samples of insulation must be tested for four hours in accordance with ASTM D 4565-90a. The temperature for the type of material is as follows:

Material	Temperature
Polyethylene	115 ± 1°C
Crystalline Propylene/Ethylene Copolymer	130 ± 1°C

2.11.5 <u>Oxygen Induction Time</u>: Samples of insulation, which have been conditioned in accordance with Paragraph 17.3 of ASTM D 4565-90a, must be tested in accordance with the procedures of ASTM D 4565-90a using copper pans and a test temperature of 199 ± 1°C.

2.12 Other methods of testing may be used if acceptable to REA.

3. IDENTIFICATION OF PAIRS AND TWISTING OF PAIRS

3.1 The insulation must be colored to identify:

a. The tip and ring conductor of each pair, and

b. Each pair in the completed wire.

3.2 The colors to be used to provide identification of the tip and ring conductor of each pair are shown in the following table:

Pair No.	Color Tip	Color Ring
1	White	Blue
2	White	Orange
3	White	Green

3.3 **Standards of Color:** The colors of the insulated conductors supplied in accordance with this specification are specified in terms of the Munsell Color System (ASTM D 1535-89) and must comply with the "Table of Wire and Cable Limit Chips" as defined in ANSI/EIA-359-A-84. (Visual color standards meeting these requirements may be obtained directly from the Munsell Color Company, Inc., 2441 North Calvert Street, Baltimore, Maryland 21218).

3.4 Positive identification of the tip and ring conductors of each pair by marking each conductor of a pair with the color of its mate is permissible. The method of marking must be accepted by REA prior to its use.

3.5 Other methods of providing positive identification of the tip and ring conductors of each pair may be employed if accepted by REA prior to its use.

3.6 The insulated conductors must be twisted into pairs.

3.7 In order to provide sufficiently high crosstalk isolation, the pair twists must be designed to enable the wire to meet the capacitance unbalance and the crosstalk loss requirements of Paragraphs 13.2, 13.3, and 13.4 of this specification.

3.8 The average length of pair twists in any pair in the finished wire, when measured on any 3 m (10 ft) length, must not exceed 152 mm (6 in.).

3.9 An alternative method of forming the two-pair wire is the use of a star-quad configuration.

3.9.1 The assembly of the star-quad must be such as to enable the wire to meet the capacitance unbalance and the crosstalk loss requirements of Paragraphs 13.2, 13.3, and 13.4 of this specification.

3.9.2 The four individual insulated conductors must be twisted together to form a star-quad configuration with the tip and ring conductors of each pair diagonally opposite each other in the quad.

3.9.3 The average length of twist for the star-quad in the finished wire, when measured on any 3 m (10 ft) length, must not exceed 152 mm (6 in.).

3.9.4 The following color scheme must be used to provide identification of the tip and ring conductor of each pair in the star-quad:

	Color	
Pair No.	Tip	Ring
1	White with blue stripe	Blue
2	White with orange stripe	Orange

3.9.5 If desired, the blue and orange conductors may contain a white stripe. The stripes in this case must be narrow enough so that the tip and ring identification is obvious.

4. FORMING OF THE WIRE CORE

4.1 Twisted pairs or star-quad configuration must be assembled in such a way as to form a substantially cylindrical group.

4.2 The filling compound must be applied to the wire core in such a way as to provide a completely filled core as is commercially practical.

4.3 If desired for manufacturing reasons, white or colored binders of nonhygroscopic and nonwicking material may be applied over the core.

5. FILLING COMPOUND

5.1 After or during the stranding operation and prior to application of the optional core wrap and inner jacket, a homogeneous filling compound free of agglomerates must be applied to the wire core. The compound must be as nearly colorless as is commercially feasible and consistent with the end product requirements and pair identification.

5.2 The filling compound must be free from dirt, metallic particles and other foreign matter. It must be applied in such a way as to fill the space within the wire core.

5.3 The filling compound must be nontoxic and present no dermal hazards.

5.4 The filling compound must exhibit the following dielectric properties at a temperature of 23 $\pm$ 3°C when measured in accordance with ASTM D 150-87 or ASTM D 4872-88.

5.4.1 The dissipation factor must not exceed 0.0015 at a frequency of 1 MHz.

5.4.2 The dielectric constant must not exceed 2.30.

5.5 The volume resistivity must not be less than 10^{12} ohm-cm at a temperature of 23 $\pm$ 3°C when measured in accordance with ASTM D 257-91 or ASTM D 4872-88.

5.6 The individual wire manufacturer must satisfy REA that the filling compound selected for use is suitable for its intended application. The filling compound must be compatible with the wire components when tested in accordance with ASTM D 4568-86 at a temperature of 80°C.

6. CORE WRAP (OPTIONAL)

6.1 When a core wrap tape is used, it must consist of a layer of nonhygroscopic and nonwicking dielectric material. The wrap must be applied with an overlap.

6.2 The core wrap must provide a sufficient heat barrier to prevent visible evidence of conductor insulation deformation or adhesion between conductors, caused by adverse heat transfer during the inner jacketing operation.

6.3 If required for manufacturing reasons, white or colored binders of nonhygroscopic and nonwicking material may be applied over the core wrap.

6.4 Sufficient filling compound must be applied to the core wrap that voids or air spaces existing between the core and inner side of the core wrap are minimized.

7. INNER JACKET

7.1 An inner jacket must be applied over the core and/or core wrap.

7.2 The jacket must be free from holes, splits, blisters, or other imperfections and must be as smooth and concentric as is consistent with the best commercial practice.

7.3 The inner jacket material and test requirements must be as specified for the outer jacket material per Paragraphs 10.3 through 10.5.4 of this specification.

7.4 The inner jacket thickness at any point must not be less than 0.5 mm (0.020 in.). The thickness must be determined from measurements on 50 mm (2 in.) samples taken not less than 0.3 m (1 ft) from either end of the wire. The average must be determined from 4 readings taken approximately 90° apart on any cross section of the samples. The maximum and minimum points must be determined by exploratory measurements. The maximum thickness minus the minimum thickness at any cross section must not exceed 43 percent of the average thickness at that cross section.

8. FLOODING COMPOUND

8.1 Sufficient flooding compound must be applied on all sheath interfaces so that voids and air spaces in these areas are minimized.

8.2 The flooding compound must be compatible with the jacket when tested in accordance with ASTM D 4568-86 at a temperature of 80°C. The floodant must exhibit adhesive properties sufficient to prevent jacket slip when tested in accordance with the requirements of Appendix A, Paragraph 3.5, of this specification.

8.3 The individual wire manufacturer must satisfy REA that the flooding compound selected for use is acceptable for the application.

9. SHIELD

9.1 A shield must be applied either longitudinally or helically over the inner jacket.

9.1.1 If the shield is applied longitudinally, it must be corrugated.

9.1.2 If the shield is applied helically, it must be smooth.

9.2 The overlap for longitudinally applied shields must be a minimum of 2 mm (0.075 in.) The overlap for helically applied shields must be a minimum of 23 percent of the tape width.

9.3 General requirements for application of the shielding material are as follows:

9.3.1 Successive lengths of shielding tapes may be joined during the manufacturing process by means of cold weld, electric weld, soldering with a nonacid flux or other acceptable means.

9.3.2 Where two ends of a metal shield are to be joined together, care shall be taken to clean the metal surfaces in order to provide for a good mechanical and electrical connection.

9.3.3 The shields of each length of wire must be tested for continuity. A one meter (3 ft) section of shield containing a factory joint must exhibit not more than 110 percent of the resistance of a shield of equal length without a joint.

9.3.4 The breaking strength of any section of a shield tape containing a factory joint must not be less than 80 percent of the breaking strength of an adjacent section of the shield of equal length without a joint.

9.3.5 The reduction in thickness of the shielding material due to the corrugating or application process must be kept to a minimum and must not exceed 10 percent at any spot.

9.3.6 The shielding material must be applied in such a manner as to enable the wire to pass the bend test as specified in Paragraph 14.3 of this specification.

9.4 The following materials are acceptable for use as wire shielding.

Standard Wire	Gopher Resistant Wire
Copper Alloy 220 (Bronze) 0.1016 ± 0.0076 mm (0.0040 ± 0.0003 in.	Copper-Clad Stainless Steel 0.1270 ± 0.0127 mm (0.0050 ± 0.0005 in.)
Copper Alloy 220 (Bronze) 0.1270 ± 0.0127 mm (0.0050 ± 0.0005 in.)	Copper Alloy 664 0.1397 ± 0.0127 mm (0.0055 ± 0.0005 in.)
	Copper-Clad Alloy Steel 0.1270 ± 0.0127 mm (0.0050 ± 0.0005 in.)

9.4.1 The copper-clad steels and copper alloy 664 shielding tapes must be capable of meeting the following performance requirements prior to application to the wire:

Property	Requirement
Tensile Strength Minimum, MPa (psi)	379 (55,000)
Tensile Yield Minimum, MPa (psi)	241 (35,000)
Elongation Minimum, percent in 50 mm (2 in.)	15

9.4.2 **Copper Alloy 220:** The shielding material, prior to application to the wire, must be in the fully annealed condition and must conform to the requirements of ASTM B 694-86 for C22000 commercial bronze.

9.4.3 **Copper-Clad Stainless Steel:** In addition to meeting the requirements of Paragraph 9.4.1 of this specification, the shielding material, prior to application to the wire, must be in the fully annealed condition and must conform to the requirements of ASTM B 694-86, with a cladding ratio of 16/68/16 and must have a minimum electrical conductivity of 28 percent IACS when measured in accordance with ASTM B 193-87.

9.4.4 **Copper Alloy 664:** In addition to meeting the requirements of Paragraph 9.4.1 of this specification, the shielding material, prior to application to the wire, must be annealed temper and must conform to the requirements of ASTM B 694-86 and must have a minimum electrical conductivity of 28 percent IACS when measured in accordance with ASTM B 193-87.

9.4.5 **Copper-Clad Alloy Steel:** In addition to meeting the requirements of Paragraph 9.4.1 of this specification, the shielding material, prior to application to the wire, must be in the fully annealed condition and the copper component must conform to the requirements of ASTM B 224-91 and the alloy steel component must conform to the requirements of ASTM A 505-87, with a cladding ratio of 16/68/16, and must have a minimum electrical conductivity of 28 percent IACS when measured in accordance with ASTM B 193-87.

10. OUTER JACKET

10.1 The outer jacket must provide the wire with a tough, flexible, protective covering which can withstand exposure to sunlight, to atmospheric temperatures and stresses reasonably expected in normal installation and service.

10.2 The jacket must be free from holes, splits, blisters, or other imperfections and must be as smooth and concentric as is consistent with the best commercial practice.

10.3 The raw material used for the outer jacket must be one of the five types listed in Paragraphs 10.3.1 through 10.3.5 of this specification. The raw material must contain an antioxidant to provide long term stabilization and the materials must contain a 2.60 ± 0.25 percent concentration of furnace black to provide ultraviolet shielding. Both the antioxidant and furnace black must be compounded into the material by the raw material supplier.

10.3.1 Low density, high molecular weight polyethylene (LDHMW) must conform to the requirements of ASTM D 1248-84(1989), Type I, Class C, Category 4 or 5, Grade J3.

10.3.2 Low density, high molecular weight ethylene copolymer (LDHMW) must conform to the requirements of ASTM D 1248-84 (1989), Type I, Class C, Category 4 or 5, Grade J3.

10.3.3 Linear low density, high molecular weight polyethylene (LLDHMW) must conform to the requirements of ASTM D 1248-84 (1989), Type I, Class C, Category 4 or 5, Grade J3.

10.3.4 High density polyethylene (HD) must conform to the requirements of ASTM D 1248-84(1989), Type III, Class C, Category 4 or 5, Grade J4.

10.3.5 Medium density polyethylene (MD) must conform to the requirements of ASTM D 1248-84(1989), Type II, Class C, Category 4 or 5, Grade J4.

10.3.6 Particle size of the carbon selected for use must not average greater than 20 nanometers.

10.3.7 Absorption coefficient must be a minimum of 400 in accordance with the procedures of ASTM D 3349-86.

10.4 The outer jacketing material removed from or tested on the wire must be capable of meeting the following performance requirements:

Property	LLDHMW, Ethylene Copolymer	LDHMW Polyethylene	HD or MD Polyethylene
Melt Flow Rate			
Percent increase from raw material Maximum		50	50
<0.41 (Initial Melt Index)	100	--	--
0.41 - 2.00 (Initial Melt Index)	50	--	--
Tensile Strength			
Minimum, MPa (psi)	12.0 (1,700)	12.0 (1,700)	16.5 (2,400)
Ultimate Elongation			
Percent, Minimum	400	400	300
Shrinkback			
Percent of Length, Maximum	5	5	5
Impact			
Failures, Maximum	2/10	2/10	2/10

10.5 **Testing Procedures:** The procedures for testing the jacket samples for compliance with Paragraph 10.4 of this specification must be as follows.

10.5.1 **Melt Flow Rate:** The melt flow rate must be as determined by ASTM D 1238-90b, Condition E. Jacketing material must be free from flooding and filling compound.

10.5.2 **Tensile Strength and Ultimate Elongation:** Test in accordance with ASTM D 4565-90a, using a jaw separation speed of 500 mm/min (20 in./min) for low density material and 50 mm/min (2 in./min) for high and medium density materials.

10.5.3 **Shrinkback:** Test in accordance with the procedures specified in ASTM D 4565-90a using a test temperature of 100 ± 1°C for low density material and a test temperature of 115 ± 1°C for high and medium density materials.

10.5.4 **Impact:** The test must be performed in accordance with ASTM D 4565-90a using an impact force of 4 N-m (3 lbf-ft) at a temperature of -20 ± 2°C. The cylinder must strike the sample at the shield overlap. A crack or split in the jacket constitutes failure.

10.6 **Jacket Thickness:** The minimum jacket thickness must be 0.64 mm (0.025 in.) except that the minimum thickness over the sheath slitting cord, if present, must be 0.46 mm (0.018 in.). The minimum point must be determined by exploratory measurements. The average thickness at any cross section must be determined from four readings including the minimum point, taken approximately 90° apart. The thickness measurement must exclude any jacket material that has formed into the corrugation. The maximum thickness at any cross section must not be greater than 155 percent of the minimum thickness.

10.7 **Eccentricity:** The eccentricity of the jacket must not exceed 43 percent when calculated using the formula as follows:

$$\frac{\text{Max. Thickness - Min. Thickness}}{\text{Average Thickness}} \times 100 \text{ Percent}$$

11. SHEATH SLITTING CORD (OPTIONAL)

11.1 Sheath slitting cords may be used in the wire structure at the option of the manufacturer.

11.2 When a sheath slitting cord is used it must be non-hygroscopic and nonwicking, continuous throughout a length of wire, and of sufficient strength to open the sheath without breaking the cord.

11.3 Sheath slittings cords must be capable of consistently slitting the jacket(s) and/or shield for a continuous length of 0.6 m (2 ft) when tested in accordance with the procedure specified in Appendix B of this specification.

12. IDENTIFICATION MARKER AND LENGTH MARKER

12.1 Each length of wire must be permanently identified as to manufacturer and year of manufacture.

12.2 The number of conductor pairs and their gauge size must be marked on the jacket.

12.3 The marking must be printed on the jacket at regular intervals of not more than 1.5 m (5 ft).

12.4 An alternative method of marking may be used if accepted by REA prior to its use.

12.5 The completed wire must have sequentially numbered length markers in FEET OR METERS at regular intervals of not more than 1.5 m (5 ft) along the outside of the jacket.

12.6 The method of length marking must be such that for any single length of wire, continuous sequential numbering must be employed.

12.7 The numbers must be dimensioned and spaced to produce good legibility and must be approximately 3 mm (0.125 in.) in height. An occasional illegible marking is permissible if there is a legible marking located not more than 1.5 m (5 ft) from it.

12.8 The method of marking must be by means of suitable surface markings producing a clear distinguishable contrasting marking acceptable to REA. Where direct or transverse printing is employed, the characters should be indented to produce greater durability of marking. Any other method of length marking must be acceptable to REA as producing a marker suitable for the field. Size, shape and spacing of numbers, durability and overall legibility of the marker will be considered in acceptance of the method.

12.9 The accuracy of the length marking must be such that the actual length of any wire section is never less than the length indicated by the marking and never more than one percent greater than the length indicated by the marking.

12.10 The color of the initial marking must be white or silver. If the initial marking fails to meet the requirements of the preceding paragraphs, it will be permissible to either remove the defective marking and re-marking with the white or silver color or leave the defective marking on the wire and re-mark with yellow. No further re-marking is permitted. Any re-marking must be on a different portion of the wire circumference than any existing marking when possible and have a numbering sequence differing from any other existing marking by at least 5,000.

12.11 Any reel of wire which contains more than one set of sequential markings must be labeled to indicate the color and sequence of marking to be used. The labeling must be applied to the reel and also to the wire.

13. ELECTRICAL REQUIREMENTS

13.1. Mutual Capacitance And Conductance:

13.1.1 The average mutual capacitance (corrected for length) of all pairs in any reel must not exceed 52 ± 4 nF/km (83 ± 7 nF/mile) when tested in accordance with ASTM D 4566-90 at a frequency of 1.0 ± 0.1 kHz and a temperature of 23 ± 3°C.

13.1.2 The mutual conductance (corrected for length and gauge) of any pair must not exceed 2 micromhos/km (3.3 micromhos/mile) when tested in accordance with ASTM D 4566-90 at a frequency of 1.0 ± 0.1 kHz and a temperature of 23 ± 3°C.

13.2 **Pair-to-Pair Capacitance Unbalance:** The capacitance unbalance between any pair of the completed wire must not exceed 145 pF/km (80 pF/1000 ft) when tested in accordance with ASTM D 4566-90 at a frequency of 1.0 ± 0.1 kHz and a temperature of 23 ± 3°C.

13.3 Pair-to-Ground Capacitance Unbalance:

13.3.1 **Pair-to-Ground:** The capacitance unbalance as measured on the individual pairs of the completed wire must not exceed 2625 pF/km (800 pF/1000 ft) when tested in accordance with ASTM D 4566-90 at a frequency of 1.0 ± 0.1 kHz and a temperature of 23 ± 3°C.

13.3.2 When measuring pair-to-ground capacitance unbalance all pairs except the pair under test are grounded to the shield.

13.3.3 Pair-to-ground capacitance unbalance may vary directly with the length of the wire.

13.4 **Far-End Crosstalk Loss:** The output-to-output far-end crosstalk loss between any pair combination of a completed wire when measured in accordance with ASTM D 4566-90 at a test frequency of 150 kHz must not be less than 58 dB/km (63 dB/1000 ft). If the loss K_O at a frequency F_O for length L_O is known, then K_X can be determined for any other frequency F_X or length L_X by:

$$\text{FEXT loss } (K_X) = K_O - 20 \log_{10} \frac{F_X}{F_O} - 10 \log_{10} \frac{L_X}{L_O}$$

13.5 **Attenuation:** The attenuation of any individual pair on any reel of wire must not exceed the following limits when measured at or corrected to a temperature of 20 ± 1°C and a test frequency of 150 kHz. The test must be conducted in accordance with ASTM D 4566-90.

Conductor AWG	Individual Pair Attenuation dB/km (dB/mile) Maximum	Minimum
22	6.8 (11.0)	5.0 (8.1)
24	8.7 (14.0)	6.6 (10.7)

13.6 Insulation Resistance: Each insulated conductor in each length of completed wire, when measured with all other insulated conductors and the shield grounded, must have an insulation resistance of not less than 1600 megohm-kilometer (1000 Megohm-mile) at 20 ± 1°C. The measurement must be made in accordance with the procedures of ASTM D 4566-90.

13.7 High Voltage Test:

13.7.1 In each length of completed wire, the insulation between conductors when tested in accordance with ASTM D 4566-90 must withstand for 3 seconds a dc potential whose value is not less than:

a. 5.0 kV for 22-gauge conductors, and

b. 4.0 kV for 24-gauge conductors.

13.7.2 In each length of completed wire, the dielectric strength between the shield and all conductors in the core must be tested in accordance with ASTM D 4566-90 and must withstand, for 3 seconds, a dc potential whose value is not less than 20 kV.

13.8 Conductor Resistance: The dc resistance of any conductor must be measured in the completed wire in accordance with ASTM D 4566-90 and must not exceed the following values when measured at or corrected to a temperature of 20 ± 1°C.

AWG	Maximum Resistance ohms/kilometer	(ohms/1000 ft)
22	57.1	(17.4)
24	90.2	(27.5)

13.9 Resistance Unbalance:

13.9.1 The difference in dc resistance between the two conductors of any pair in the completed wire must not exceed 5.0 percent when measured in accordance with the procedures of ASTM D 4566-90.

13.9.2 The resistance unbalance between tip and ring conductors shall be random with respect to the direction of unbalance. That is, the resistance of the tip conductors shall not be consistently higher with respect to the ring conductors and vice versa.

14. MECHANICAL REQUIREMENTS

14.1 <u>Defective Wire:</u> Pairs in each length of wire will not be permitted to have either a ground, cross, short or open circuit condition.

14.2 <u>Wire Breaking Strength:</u> The breaking strength of the completed wire must not be less than 890 N (200 lbf) when tested in accordance with ASTM D 4565-90a using a jaw separation speed of 25 mm/min (1.0 in./min).

14.3 <u>Wire Bending Test:</u> The completed wire must be capable of meeting the requirements of ASTM D 4565-90a after conditioning at -20 ± 2°C and at 23 ± 2°C.

14.4 <u>Water Penetration Test:</u>

14.4.1 A one meter (3 ft) length of completed wire must be stabilized at 23 ± 2°C and tested in accordance with ASTM D 4565-90a using a one meter (3 ft) water head over the sample or placed under the equivalent continuous pressure for one hour.

14.4.2 After the one hour period, there must be no water leakage in the sheath interfaces, under the core wrap or between any insulated conductors in the core.

14.4.3 If water leakage is detected in the first sample, one 3 m (10 ft) additional adjacent sample from the same reel of wire shall be tested in accordance with Paragraph 14.4.2 of this specification. If the second sample exhibits water leakage, the entire reel of wire is to be rejected. If the second sample exhibits no leakage, the entire reel of wire is considered acceptable.

14.5 <u>Compound Flow Test:</u> The completed wire must be capable of meeting the compound flow test specified in ASTM D 4565-90a when exposed for a period of 24 hours at a temperature of 80 ± 1°C. At the end of this test period, there must be no evidence of flowing or dripping of compound from either the core or sheath interfaces.

15. ACCEPTANCE TESTING AND EXTENT OF TESTING

15.1 The tests described in Appendix A of this specification are intended for acceptance of wire designs and major modifications of accepted designs. REA decides what constitutes a major modification. These tests are intended to show the inherent capability of the manufacturer to produce wire products having long life and stability.

15.2 For initial acceptance, the manufacturer must submit:

a. An original signature certification that the product fully complies with each section of this specification;

b. Qualification Test Data, per Appendix A of this specification;

c. To periodic plant inspections;

d. A certification that the product does or does not comply with the domestic origin manufacturing provisions of the "Buy American" requirements of the Rural Electrification Act of 1938 (7 U.S.C. 901 et seq.);

e. Written user testimonials concerning performance of the product; and

d. Other nonproprietary data deemed necessary by the Chief, Outside Plant Branch (Telephone).

15.3 For requalification acceptance, the manufacturer must submit an original signature certification that the product fully complies with each section of the specification, excluding the Qualification Section, and a certification that the product does or does not comply with the domestic origin manufacturing provisions of the "Buy American" requirements of the Rural Electrification Act of 1938 (7 U.S.C. 901 et seq.) for acceptance by June 30 every three years. The required data and certification must have been gathered within 90 days of the submission.

15.4 Initial and requalification acceptance requests should be addressed to:

Chairman, Technical Standards
Committee "A" (Telephone)
Telecommunications Standards Division
Rural Electrification Administration
Washington, D.C. 20250-1500

15.5 **<u>Tests on 100 percent of completed wire:</u>**

15.5.1 The shield of each length of wire must be tested for continuity using the procedures of ASTM D 4566-90.

15.5.2 Dielectric strength between all conductors and the shield must be tested to determine freedom from grounds in accordance with Paragraph 13.7.2 of this specification.

15.5.3 Each conductor in the completed wire must be tested for continuity using the procedures of ASTM D 4566-90.

15.5.4 Dielectric strength between conductors must be tested to ensure freedom from shorts and crosses in accordance with Paragraph 13.7.1 of this specification.

15.5.5 The average mutual capacitance must be measured on all wires.

15.6 **Capability Tests:** Tests on a quality assurance basis must be made as frequently as is required for each manufacturer to determine and maintain compliance with:

15.6.1 Performance requirements for conductor insulation and jacket material;

15.6.2 Performance requirements for filling and flooding compounds;

15.6.3 Sequential marking and lettering;

15.6.4 Capacitance unbalance and crosstalk;

15.6.5 Insulation resistance;

15.6.6 Conductor resistance and resistance unbalance;

15.6.7 Wire bending and wire breaking strength tests;

15.6.8 Mutual conductance and attenuation; and

15.6.9 Water penetration and compound flow tests.

16. SUMMARY OF RECORDS OF ELECTRICAL AND PHYSICAL TESTS

16.1 Each manufacturer must maintain suitable summary of records for a period of at least 3 years for all electrical and physical tests required on completed wire by this specification as specified in Paragraphs 15.5 and 15.6 of this specification. The test data for a particular reel shall be in a form that it may be readily available to the purchaser or to REA upon request.

16.2 Measurements and computed values must be rounded off to the number of places of figures specified for the requirement according to ASTM E 29-90.

17. MANUFACTURING IRREGULARITIES

17.1 Repairs to the inner jacket and shield are not permitted in wire supplied to the end user under this specification.

17.2 Minor defects in the outer jackets (defects having a dimension of 3 mm (0.125 in.) or less in any direction) may be repaired by means of heat fusing in accordance with good commercial practices utilizing sheath grade compound.

18. PREPARATION FOR SHIPMENT

18.1 The wire must be shipped on reels. The diameter of the drum must be large enough to prevent damage to the wire from reeling or unreeling. The reels must be substantial and so constructed as to prevent damage to the wire during shipment and handling.

18.2 The thermal wrap must comply with the requirements of Appendix C of this specification. When a thermal reel wrap is supplied, the wrap must be applied to the reel and must be suitably secured in place to minimize thermal exposure to the wire during storage and shipment. The use of the thermal reel wrap as an means of reel protection will be at the option of the manufacturer unless specified by the end user.

18.3 The outer end of the wire must be securely fastened to the reel head so as to prevent the wire from becoming loose in transit. The inner end of the wire must be securely fastened in such a way as to make it readily available if required for electrical testing. Spikes, staples, or other fastening devices which penetrate the wire jacket must not be used. The method of fastening the wire ends must be accepted by REA prior to it being used.

18.4 Each length of wire must be wound on a separate reel unless otherwise specified or agreed to by the purchaser.

18.5 Each reel must be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the wire on the reel.

18.6 Each reel must be stenciled or labeled on either one or both sides with the name of the manufacturer, year of manufacture, actual shipping length, an inner and outer end sequential length marking, description of the wire, reel number and the REA wire designation.

<u>WIRE DESIGNATION</u>

BFW...
Wire Construction...
Pair Count...
Conductor Gauge...

N = Copper Alloy 220 (Bronze) Shield
Y = Gopher Resistant Shields

Example: BFWY 3-24

Buried Filled Wire, Gopher Resistant Shield, 3 pair, 24 AWG

18.7 Both ends of the filled buried wire, manufactured to the requirements of this specification, must be equipped with end caps which are acceptable to REA.

(The information and recordkeeping requirements of this specification have been approved by the Office of Management and Budget (0MB) under Control Number 0572-0077).

UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

APPENDIX A

FILLED BURIED WIRE

Qualifications Test Methods Bulletin 1753F-206(PE-86)

1. The test procedures described in this appendix are for qualification of initial designs and major modifications of "accepted" designs. Included in Paragraph 5 of this appendix are suggested formats that may be used in submitting test results to REA.

2. SAMPLE SELECTION AND PREPARATION

2.1 All testing must be performed on lengths removed sequentially from the same 3 pair, 22 gauge jacketed wire. This wire must not have been exposed to temperatures in excess of 38°C since its initial cool down after sheathing. The lengths specified are minimum lengths and if desirable from a laboratory testing standpoint longer lengths may be used.

2.1.1 Length A shall be 10 ± 0.2 m (33 ± 0.5 ft) long and must be maintained at 23 ± 3°C. One length is required.

2.1.2 Length B shall be 12 ± 0.2 m (40 ± 0.5 ft) long. Prepare the test sample by removing the inner and outer jacket, shield and core wrap, if present, for a sufficient distance on both ends to allow the insulated conductors to be flared out. Remove sufficient conductor insulation so that appropriate electrical test connections can be made at both ends. Coil the specimen with a diameter of 15 to 20 times its sheath diameter. Three lengths are required.

2.1.3 Length C shall be one meter (3 ft) long. Four lengths are required.

2.1.4 Length D shall be 300 mm (1 ft) long. Four lengths are required.

2.1.5 Length E shall be 600 mm (2 ft) long. Four lengths are required.

2.1.6 Length F shall be 3 m (10 ft) long and must maintained at 23 ± 3°C for the duration of the test. Two lengths are required.

2.2 **Data Reference Temperature**: Unless otherwise specified, all measurements shall be made at 23 ± 3°C.

3. ENVIRONMENTAL TESTS

3.1 Heat Aging Test

3.1.1 Test Samples: Place one sample each of lengths B, C, D, and E in an oven or environmental chamber. The ends of sample B must exit from the chamber or oven for electrical tests. Securely seal the oven exit holes.

3.1.2 Sequence of Tests: After conditioning the samples are to be subjected to the following tests:

a. Water Immersion Test outlined in Paragraph 3.2 of this appendix.

b. Water Penetration Test outlined in Paragraph 3.3 of this appendix.

c. Insulation Compression Test outlined in Paragraph 3.4 of this appendix.

d. Jacket Slip Strength Test outlined in Paragraph 3.5 of this appendix.

3.1.3 Initial Measurements

3.1.3.1 For sample B, measure the open circuit capacitance and conductance for each pair at 1 and 150 kHz and the attenuation at 150 kHz after conditioning the sample at the data reference temperature for 24 hours. Calculate the average and standard deviation for the data of the 3 pairs on a per kilometer (per mile) basis.

3.1.3.2 The attenuation at 150 kHz may be calculated from Yoc and Zsc or may be obtained by direct measurement of attenuation.

3.1.3.3 Record on suggested formats attached in Paragraph 5 of this appendix or on other easily readable formats.

3.1.4 Heat Conditioning

3.1.4.1 Immediately after completing the initial measurements, condition the sample for 14 days at a temperature of 65 $\pm$ 2°C.

3.1.4.2 At the end of this period note any exudation of filling compounds. Measure and calculate the parameters given in Paragraph 3.1.3 of this appendix. Record on suggested formats in Paragraph 5 of this appendix or on other easily readable formats.

3.1.4.3 Cut away and discard a one meter (3 ft) section from each end of length B.

3.1.5 Overall Electrical Deviation

3.1.5.1 Calculate the percent change in all average parameters between the final parameters after conditioning with the initial parameters in Paragraph 3.1.3 of this appendix.

3.1.5.2 The stability of the electrical parameters after completion of the test must be within the following prescribed limits:

a. Capacitance: The average mutual capacitance must be within 5 percent of its original value;

b. The change in average mutual capacitance must be less than 5 percent over the frequency range of 1 to 150 kHz;

c. Conductance: The average mutual conductance must not exceed 2 micromhos/kilometer (3.3 micromhos/mile) at a frequency of 1 kHz; and

d. Attenuation: The attenuation must not have increased by more than 5 percent over its original value.

3.2 Water Immersion Electrical Test

3.2.1 Test Sample Selection: The 10 m (33 ft) section of length B must be tested.

3.2.2 Test Sample Preparation: Prepare the sample by removing the inner and outer jacket, shield, and core wrap, if present, for a sufficient distance to allow one end to be accessed for test connections. Cut out a series of 2.5 mm by 13 mm (0.1 in. by 0.5 in.) rectangular slots along the test sample, at 300 mm (1 ft) intervals progressing successively 90 degrees around the circumference of the wire. Assure that the wire core is exposed at each slot by slitting the inner jacket and core wrap if present. Place the prepared sample in a dry vessel which when filled will maintain a one meter (3 ft) head of water over 6 m (20 ft) of uncoiled wire. Extend and fasten the ends of the wire so they will be above the water line and the pairs are rigidly held for the duration of the test.

3.2.3 Capacitance and Conductance Testing: Measure the initial values of mutual capacitance and conductance of all pairs in each wire at a frequency of 1 kHz before filling the vessel with water. Be sure the wire shield is grounded to the test equipment. Fill the vessel until there is a one meter (3 ft) head of water on the wires.

3.2.3.1 Remeasure the mutual capacitance and conductance after the wires have been submerged for 24 hours and again after 30 days.

3.2.3.2 Record each sample separately on the suggested formats attached in Paragraph 5 of this appendix or on other easily readable formats.

3.2.4. <u>Overall Electrical Deviation</u>

3.2.4.1 Calculate the percent change in all average parameters between the final parameters after conditioning with the initial parameters in Paragraph 3.2.3 of this appendix.

3.2.4.2 The stability of the electrical parameters after of the test must be within the following prescribed limits:

a. <u>Capacitance:</u> The average mutual capacitance must be within 5 percent of its original value; and

b. <u>Conductance:</u> The average mutual conductance must not exceed 2 micromhos/kilometer (3.3 micromhos/mile) at a frequency of 1 kHz.

3.3 <u>Water Penetration Testing</u>

3.3.1 A watertight closure must be placed over the jacket of length C. The closure must not be placed over the jacket so tightly that the flow of water through pre-existing voids or air spaces is restricted. The other end of the sample must remain open.

3.3.2 Test as per Option A or Option B.

3.3.2.1 <u>Option A</u>: Weigh the sample and closure prior to testing. Fill the closure with water and place under a continuous pressure of 10 $\pm$ 0.7 kPa (1.5 $\pm$ 0.1 psig) for one hour. Collect the water leakage from the end of the test sample during the test and weigh to the nearest 0.1 g. Immediately after the one hour test, seal the ends of the wire with a thin layer of grease and remove all visible water from the closure, being careful not to remove water that penetrated into the core during the test. Reweigh the sample and determine the weight of water that penetrated into the core. The weight of water that penetrated into the core must not exceed 1 gram.

3.3.2.2 <u>Option B</u>: Fill the closure with a 0.2 g sodium fluorscein per liter water solution and apply a continuous pressure of 10 $\pm$ 0.7 kPa (1.5 $\pm$ 0.1 psig) for one hour. Catch and weigh any water that leaks from the end of the wire during the one hour period. If no water leaks from the sample, carefully remove the water from the closure. Then carefully remove the outer jacket, shield, inner jacket and core wrap, if present, one at a time, examining with an ultraviolet light source for water penetration. After removal of the inner jacket and core wrap, if present, carefully dissect the core and examine for water penetration within the core. Where water penetration is observed, measure the penetration distance. The distance of water penetration into the core must not exceed 127 mm (5.0 in.).

3.4 Insulation Compression Test

3.4.1 Test Sample D. Remove inner and outer jacket, shield and core wrap, if present, being careful not to damage the conductor insulation. Remove one pair from the core and carefully separate, wipe off core filler and straighten the insulated conductors. Retwist the two insulated conductors together under sufficient tension to form 10 evenly spaced 360 degree twists in a length of 100 mm (4 in.).

3.4.2 Sample Testing: Center the mid 50 mm (2 in.) of the twisted pair between two smooth rigid parallel metal plates measuring 50 mm (2 in.) in length or diameter. Apply a 1.5 volt dc potential between the conductors, using a light or buzzer to indicate electrical contact between the conductors. Apply a constant load of 67 N (15 lbf) on the sample for one minute and monitor for evidence of contact between the conductors. Record results on suggested formats attached in Paragraph 5 of this appendix or on other easily readable formats.

3.5 Jacket Slip Strength Test

3.5.1 Sample Selection: Test sample E from Paragraph 3.1.1 of this specification.

3.5.2 Sample Preparation: Prepare test sample in accordance with the procedures specified in ASTM D 4565-90a.

3.5.3 Sample Conditioning and Testing: Remove the sample from the tensile tester prior to testing and condition for one hour at 50 $\pm$ 2°C. Test immediately in accordance with the procedure specified in ASTM D 4565-90a. A minimum outer jacket slip strength of 67 N (15 lbf) is required. Record the load attained.

3.6 Humidity Exposure

3.6.1 Repeat steps 3.1.1 through 3.1.3.3 of this appendix for separate set of samples B, C, D and E which have not been subjected to prior environmental conditioning.

3.6.2 Immediately after completing the measurements, expose the test sample to 100 temperature cyclings. Relative humidity within the chamber must be maintained at 90 $\pm$ 2 percent. One cycle consists of beginning at a stabilized chamber and test sample temperature of 52 $\pm$ 1°C, increasing the temperature to 57 $\pm$ 1°C, allowing the chamber and test samples to stabilize at this level, then dropping the temperature back to 52 $\pm$ 1°C.

3.6.3 Repeat steps 3.1.4.2 through 3.5.3 of this appendix.

3.7 <u>Temperature Cycling</u>

3.7.1 Repeat steps 3.1.1 through 3.1.3.3 of this appendix for separate set of samples B, C, D and E which have not been subjected to prior environmental conditioning.

3.7.2 Immediately after completing the measurements, subject the test sample to 10 cycles of temperature between -40°C and +60°C. The test sample must be held at each temperature extreme for a minimum of 1 1/2 hours during each cycle of temperature. The air within the temperature cycling chamber must be circulated throughout the duration of the cycling.

3.7.3 Repeat steps 3.1.4.2 through 3.5.3 of this appendix.

4. CONTROL SAMPLE

4.1 <u>Test Samples</u>: A separate set of lengths for samples A, C, D, and E must have been maintained at 23 ± 3°C for at least 48 hours before the testing.

4.2 Repeat steps 3.2 through 3.5.3 of this appendix except use length A instead of length B.

4.3 <u>Surge Test</u>

4.3.1 One length of sample F must be used to measure the breakdown between conductors while the other length of F must be used to measure core to shield breakdown.

4.3.2 The samples must be capable of withstanding, without damage, a single surge voltage of 20 kV peak between conductors, and 35 kV peak between conductors and the shield as hereinafter described. The surge voltage must be developed from a capacitor discharge through a forming resistor connected in parallel with the dielectric of the test sample. The surge generator constants must be such as to produce a surge of 1.5 x 40 microseconds wave shape.

4.3.3 The shape of the generated wave must be determined at a reduced voltage by connecting an oscilloscope across the forming resistor with the wire sample connected in parallel with the forming resistor. The capacitor bank is charged to the test voltage and then discharged through the forming resistor and test sample. The test sample will be considered to have passed the test if there is no distinct change in the wave shape obtained with the initial reduced voltage compared to that obtained after the application of the test voltage.

5. TEST DATA FORMATS

5.1 The following suggested formats may be used for submitting the test data to REA.

ENVIRONMENTAL CONDITIONING

FREQUENCY 1 kHz

PAIR NUMBER	CAPACITANCE nF/km (nF/mile)		CONDUCTANCE micromhos/km (micromhos/mile)	
	Initial	Final	Initial	Final
1	________	______	________	______
2	________	______	________	______
3	________	______	________	______
Average $\bar{x}$	________	______	________	______
Overall Percent Difference in Average $\bar{x}$	______________		______________	

ENVIRONMENTAL CONDITIONING

FREQUENCY 150 kHz

PAIR NUMBER	CAPACITANCE nF/km (nF/mile)		CONDUCTANCE micromhos/km (micromhos/mile)		ATTENUATION dB/km (dB/mile)	
	Initial	Final	Initial	Final	Initial	Final
1	______	______	______	______	______	______
2	______	______	______	______	______	______
3	______	______	______	______	______	______
Average $\bar{x}$	______	______	______	______	______	______
Overall Percent Difference in Average $\bar{x}$	______		______		______	

ENVIRONMENTAL CONDITIONING

WATER IMMERSION TEST (1 kHz)

PAIR NUMBER	CAPACITANCE nF/km (nF/mile)			CONDUCTANCE micromhos/km (micromhos/mile)		
	Initial	24 hours	Final	Initial	24 hours	Final
1	________	________	______	________	________	______
2	________	________	______	________	________	______
3	________	________	______	________	________	______
Average $\bar{x}$	________	________	______	________	________	______
Overall Percent Difference in Average $\bar{x}$	________________			________________		

WATER PENETRATION TEST

	Option A		Option B	
	End Leakage g	Weight Gain g	End Leakage g	Penetration mm (in.)
Control	____________	____________	____________	____________
Heat Age	____________	____________	____________	____________
Humidity Exposure	____________	____________	____________	____________
Temperature Cycling	____________	____________	____________	____________

INSULATION COMPRESSION

	Failures
Control	_________
Heat Age	_________
Humidity Exposure	_________
Temperature Cycling	_________

JACKET SLIP STRENGTH @ 50°C

	Load in N (1bf)
Control	________________
Heat Age	________________
Humidity Exposure	________________
Temperature Cycling	________________

FILLER EXUDATION (g)

Heat Age	________________
Humidity Exposure	________________
Temperature Cycle	________________

SURGE TEST (kV)

Conductor to Conductor	________________
Shield to Conductors	________________

UNITED STATED DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

APPENDIX B

Sheath Slitting Cord Qualification

1. The test procedures described in this appendix are for qualification of initial and subsequent changes in sheath slitting cords.

2. SAMPLE SELECTION: All testing must be performed on two 1.2 m (4 ft) length of wire removed sequentially from the same 3 pair, 22 gauge jacketed wire. This wire must not have been exposed to temperatures in excess of 38°C since its initial cool down after sheathing.

3. TEST PROCEDURE

3.1 Using a suitable tool, expose enough of sheath slitting cord to permit grasping with needle nose pliers.

3.2 The prepared test specimens shall be maintained at a temperature of 23 ± 1°C for at least 4 hours immediately prior to and during the test.

3.3 Wrap the sheath slitting cord around the plier jaws to ensure a good grip.

3.4 Grasp and hold the wire in a convenient position while gently and firmly pulling the sheath slitting cord longitudinally in the direction away from the wire end. The angle of pull may vary to any convenient and functional degree. A small starting notch is permissible.

3.5 The sheath slitting cord is considered acceptable if the cord can slit the jacket and/or shield for a continuous length of 0.6 m (2 ft) without breaking the cord.

UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

APPENDIX C

Thermal Reel Wrap Qualification

1. The test procedures described in this appendix are for qualification of initial and subsequent changes in thermal reel wraps.

2. SAMPLE SELECTION: All testing must be performed on two 450 mm (18 in.) lengths of wire removed sequentially from the same 3 pair, 22 gauge jacketed wire. This wire must not have been exposed to temperatures in excess of 38°C since its initial cool down after sheathing.

3. TEST PROCEDURE

3.1 Place the two samples on an insulating material such as wood, etc.

3.2 Tape thermocouples to the jackets of each sample to measure the jacket temperature.

3.3 Cover one sample with the thermal reel wrap.

3.4 Expose the samples to a radiant heat source capable of heating the uncovered jacket sample to a minimum of 71°C. A 600 watt photoflood lamp or an equivalent lamp having the light spectrum approximately that of the sun shall be used.

3.5 The height of the lamp above the jacket shall be 380 mm (15 in.) or a height that produces the 71°C jacket temperature on the unwrapped sample.

3.6 After the samples have stabilized at the temperature, the jacket temperatures of the samples must be recorded after one hour of exposure to the heat source.

3.7 Compute the temperature difference between the jackets.

3.8 For the thermal reel wrap to be acceptable to REA, the temperature differences between the jacket with the thermal reel wrap and the jacket without the reel wrap must be greater than or equal to 17°C.